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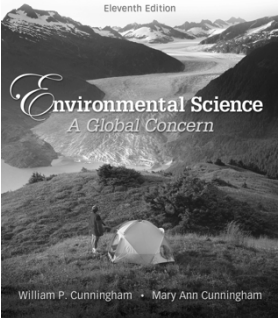
Chapter 14

Lecture Outline*

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*See PowerPoint Image Slides for all figures and tables pre-inserted into PowerPoint without notes.

Eleventh Edition



Environmental Science
A Global Concern


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Geology and Earth Resources

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Outline

- Tectonic Processes
- Rocks and Minerals
 - ✦ Rock Cycle
- Economic Geology and Mineralogy
- Environmental Effects of Resource Extraction
 - ✦ Mining
 - Reclamation
- Conserving Geological Resources
- Geological Hazards

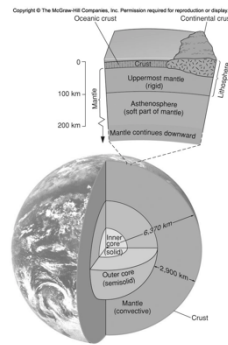
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Earth is a Dynamic Planet

- A Layered Sphere
 - ❖ Core - interior composed of dense, intensely hot metal, mostly iron. Generates magnetic field enveloping the earth.
 - ❖ Mantle - hot, pliable layer surrounding the core. Less dense than core.
 - ❖ Crust - cool, lightweight, brittle outermost layer. Floats on top of mantle.

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Earth's Cross Section

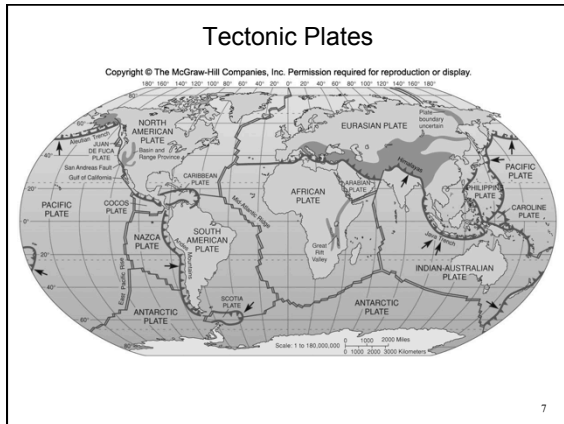


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Tectonic Processes

- Upper layer of mantle contains convection currents that break overlying crust into a mosaic of tectonic plates.
 - ❖ Slide slowly across earth's surface
 - Ocean basins form where continents crack and pull apart.
 - Magma (molten rock) forced up through the cracks forms new oceanic crust that piles up underwater in mid-ocean ridges.

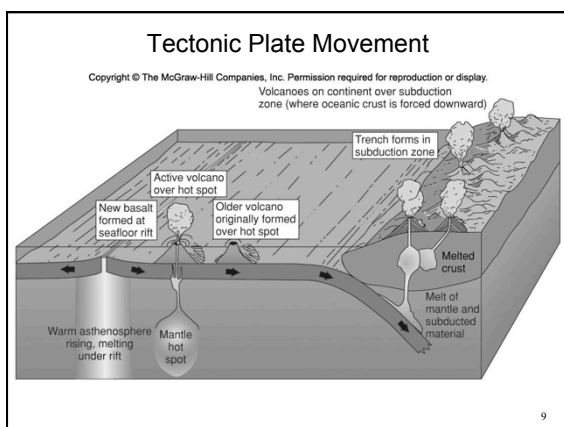
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Tectonic Processes

- Earthquakes are caused by grinding and jerking as plates slide past each other.
- ❖ Mountain ranges pushed up at the margins of colliding plates.
 - When an oceanic plate collides with a continental landmass, the continental plate will ride up over the seafloor and the oceanic plate will subduct down into the mantle where it melts.
 - Deep ocean trenches mark subduction zones.

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Pangaea

- Geologists suggest that several times in Earth's history most, or all, of the continents gathered to form a single super-continent, Pangaea, surrounded by a single global ocean.
- The redistribution of continents affects the Earth's climate and may help explain the periodic mass extinction of organisms.

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Pangaea

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200 million years ago



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Rocks and Minerals

- A mineral is a naturally occurring, inorganic, solid element or compound with a definite chemical composition and regular internal crystal structure.
- A rock is a solid, cohesive, aggregate of one or more minerals.
 - ❖ Each rock has a characteristic mixture of minerals, grain sizes, and ways in which the grains are held together.

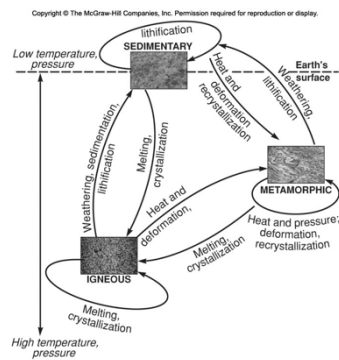
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Rock Types

- Rock Cycle - cycle of creation, destruction, and metamorphosis
 - ❖ Three major rock classifications:
 - Igneous
 - Sedimentary
 - Metamorphic

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Rock Cycle



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Igneous Rocks

- Most common type of rock in Earth's crust.
 - ❖ Solidified from magma extruded onto the surface from volcanic vents
 - Quick cooling of magma produces fine-grained rocks.
 - Basalt
 - Slow cooling of magma produces coarse-grained rocks.
 - Granite

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Metamorphic Rock

- Pre-existing rocks modified by heat, pressure, and chemical agents
 - ✦ Chemical reactions can alter both the composition and structure of rocks as they are metamorphosed.
 - Marble (from limestone)
 - Quartzite (from sandstone)
 - Slate (from mudstone and shale)

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Weathering and Sedimentation

- Mechanical weathering - physical break-up of rocks into smaller particles without a change in chemical composition
- Chemical weathering - selective removal or alteration of specific components that leads to weakening and disintegration of rock
 - ✦ Oxidation
 - ✦ Hydrolysis
- Sedimentation - deposition of particles of rock transported by wind, water, ice and gravity until they come to rest in a new location

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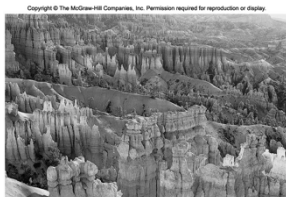
Sedimentary Rock

- Deposited materials that remain in place long enough, or are covered with enough material for compaction, may again become rock. Examples: Sandstone, shale
- Also can be formed from crystals that precipitate out of, or grow from, a solution. Example: Halite
- Sedimentary rock can be shaped by erosion.
- Geomorphology is the study of the processes that shape the earth's surface and the structures they create.
- Humans shape the Earth's surface more than any other single geomorphic process except plate tectonics.

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Sedimentary Rock

- The sedimentary rock of Bryce Canyon National Park has been carved by erosion into tall spires.



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Economic Geology

- Economic mineralogy is the study of minerals that are valuable for manufacturing.

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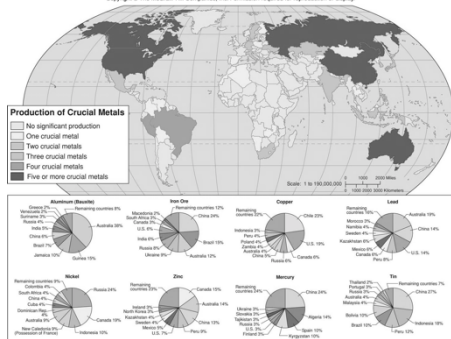
TABLE 14.2

Metal	Use
Aluminum	Packaging foods and beverages (38%), transportation, electronics
Chromium	High-strength steel alloys
Copper	Building construction, electric and electronic industries
Iron	Heavy machinery, steel production
Lead	Leaded gasoline, car batteries, paints, ammunition
Manganese	High-strength, heat-resistant steel alloys
Nickel	Chemical industry, steel alloys
Platinum-group	Automobile catalytic converters, electronics, medical uses
Gold	Medical, aerospace, electronic uses; accumulation as monetary standard
Silver	Photography, electronics, jewelry

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World Production of Metals

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Economic Geology and Mineralogy

- Metals
 - ✧ Metals consumed in greatest quantity by world industry (metric tons annually):
 - Iron (740 million)
 - Aluminum (40 million)
 - Manganese (22.4 million)
 - Copper and Chromium (8 million ea)
 - Nickel (0.7 million)

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Non-Metal Mineral Resources

- Gemstones and Precious Metals
 - ✧ Their monetary value bankrolls despots, criminal gangs, terrorism, inhumane labor conditions.
- Sand and Gravel - greatest volume and dollar value
 - ✧ Brick and concrete construction, paving, sandblasting and glass production
- Limestone
 - ✧ Concrete and building stone, plaster, cement
- Evaporites
 - ✧ Gypsum for wallboard, salt for roads
- Sulfur
 - ✧ Sulfuric acid for car batteries

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Environmental Effects of Mining

- Disturbance or removal of land surface
- 80,000 metric tons of dust
- Toxic air pollutants
- Chemical and sediment runoff
 - ✧ When sulfur bearing minerals are exposed to air and water, they produce sulfuric acid.
- Vast quantities of ore must be crushed and washed to obtain small quantities of metal; enormous amounts of freshwater are thereby contaminated with acid, arsenic, heavy metal.

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Environmental Effects of Mining

- Mining
 - ❖ Placer Mining - hydraulically washing out metals deposited in streambed gravel by using water cannons to blast away stream beds
 - Destroys streambeds and fills water with suspended solids.
- Underground mining - tunneling into mineral seams
 - ❖ Tunnels can collapse.
 - ❖ Natural gas explosions
 - ❖ Water seeping into mine shafts dissolves toxic minerals and contaminates groundwater.
 - ❖ Fires in mines which burn for years

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Environmental Effects of Mining



- Open pit or strip mining creates huge holes in the earth which fill with contaminated groundwater. Surface material is left in long ridges called spoil banks, but because they do not contain topsoil, there is often no vegetation for many years.

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Restoration

- Surface Mining Control and Reclamation Act (1977) requires better restoration of strip-mined lands, especially if land classed as prime farmland.
 - ❖ Difficult and expensive
 - Complete reclamation often costs more than \$10,000 / hectare.
 - 50% of U.S. coal is strip mined.

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Mining

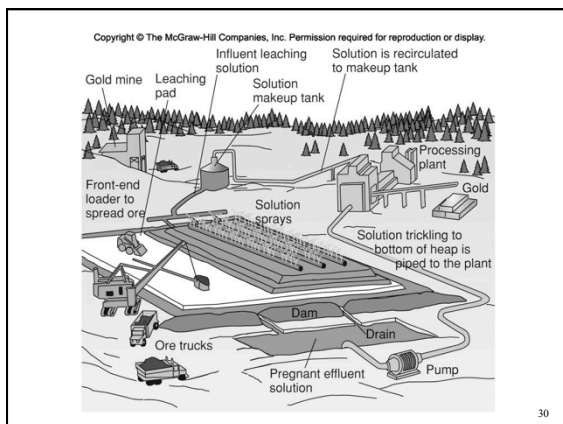
- Mining companies have recently begun to remove Appalachian coal via mountaintop removal.
- Ridge tops are removed to access a coal bed. The material from the ridge top is crushed and dumped into adjacent river valleys, burying streams.
- Lawyers sued over violation of Clean Water Act; Bush issued "clarification" of Clean Water Act permitting the destruction.

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Processing Ores

- Metals are extracted from ores by heating or treatment with chemical solvents.
 - ❖ Smelting - roasting ore to release metals
 - Major source of air pollution
 - ❖ Heap-Leach Extraction - crushed ore piled in large heaps and sprayed with a dilute alkaline cyanide solution which percolates through the pile to dissolve the gold
 - Effluent left behind in ponds can leak into surface water or groundwater.

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Conserving Geologic Resources

- Recycling
 - ❖ Aluminum must be extracted from bauxite by electrolysis.
 - Recycling waste aluminum consumes one-twentieth the energy of extraction from raw ore.
 - Nearly two-thirds of all aluminum beverage cans in U.S. are recycled.
 - ❖ Other metals commonly recycled:
 - Platinum, gold, copper, lead, iron, steel

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Substituting New Materials for Old

- Reduce metal consumption by using new materials or new technologies.
 - ❖ Metal pipes replaced by plastic pipes
 - ❖ Metal wires replaced by fiber optics
 - ❖ Steel replaced by polymers, aluminum, ceramics and new alloys

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Geologic Hazards

- Asteroid impact wiped out dinosaurs.
- Floods take the greatest number of lives, while wind causes the most property damage.
- Earthquakes - sudden movements of the Earth's crust that occur along faults where one rock mass slides past another
 - ❖ Gradual movement - called creep or seismic slip
 - When friction prevents creep, stress builds up until eventually released with a sudden jerk.
 - Point at which first movement occurs is called the epicenter.

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Earthquakes continued

- Worst death tolls from earthquake occur when construction is poor. Now buildings in earthquake zones are reinforced.
- Most seismically active region in U.S. is west coast, but largest earthquake recorded was in New Madrid, Missouri.
- Earthquakes followed by aftershocks
- Tsunami can be generated by earthquakes as we saw in 2004.
 - ❖ U.S. has installed warning buoys in ocean.

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Seismic Map of Earthquake Risk in the US

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Volcanoes

- Volcanoes and undersea magma vents are the sources of most of the Earth's crust.
 - ❖ Many of world's fertile soils are weathered volcanic material.
 - ❖ 500 million people live in danger zones.
 - ❖ Nuees ardentes - deadly clouds of hot gas and ash like those that destroyed Pompeii. Temperatures exceed 1000 degrees C. and they move at 60 mph. Kill in minutes.
 - ❖ Mudslides often accompany eruptions.
 - ❖ Volcanic dust and sulfur emissions reduce sunlight and temperature around the globe.

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Eruption of the Mayon Volcano in Philippines

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Chris G. Newhall/U.S. Geological Survey

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Landslides

- Landslides are examples of mass wasting, in which geologic materials are moved downslope from one place to another.
 - ❖ Can be slow and subtle or swift as in rockslides and avalanches
- Road construction, forest clearing, cultivation, and building on steep, unstable slopes increase the frequency and damage done by landslides.

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Landslide in Pacific Palisades, California

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